

Air Convection Noise of Pencil-beam Interferometer for Long Trace Profiler

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The task of designing high performance X-ray optical systems suitable for submicron focusing requires improvement of dedicated metrology instrumentation to sub-microradian accuracy of low-spatial-frequency slope measurement. All elements of the instrument must be free of any systematic error and noise to at least this level. In particular, in the case of a pencil-beam interferometer in a long trace profiler (LTP), this requires a corresponding pointing stability of the light beam.

In the present work, we investigate the effect of air convection on laser-beam pointing noise described with noise power density (NPD) frequency distributions. It is shown that the NPD spectra due to air convection have a very characteristic form. In the range of frequencies from ~ 0.05 Hz to ~ 0.5 Hz, the spectra can be modeled with an inverse-power-law function. Depending on the intensity of air convection that is controlled with a resistive heater of 100 to 150 mW along a one-meter-long optical path, the power index lies between 2 and 3 at the overall rms noise of ~ 0.5 to 1 microradian. Similar behavior of power spectral density (PSD) distributions measured with the LTP was recently observed [V. V. Yashchuk, et al., Proc. of SPIE 59210G]. The similarity of observed NPD and PSD spectra allows the assumption that the LTP measurements are significantly affected by the air convection.

The efficiency of suppression of the convection noise by blowing air across the beam optical path is also discussed. Air-blowing leads to a white-noise-like spectrum. The ability to change the spectral characteristics of the air turbulence on the beam pointing stability allows one to investigate the contribution of the convection effect and thus make corrections to the measured PSD spectra.

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